

## (5) NMR of heteronuclei - paramagnetism

Comparison of diamagnetic and paramagnetic parameters

### diamagnetic

- Indirect (scalar) coupling  
*J coupling*  
(Fermi contact interaction)  
4-5 bonds

- Direct coupling  
*dipole-dipole coupling*  
(through space)  
4-5 Å, proportional  $r^6$

### paramagnetic

- contact shift contribution  
 $\delta^{CS}$   
(Fermi contact shift)  
5-6 bonds

- pseudocontact shift  
 $\delta^{PCS}$   
(long-range through space)  
20-30 Å, proportional  $r^6$